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Philip H. Dewey, Secretary

TOPOGRAPHIC AND GEOLOGIC SURVEY

George H. Ashley, State Geologist.

GAS IN THE TIOGA REGION, PENNA.

By

ASHLEY AND CATHCART

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* Continued study in this region has made so much additional material available that if all were included here it would materially increase the size, cost of preparation and mailing of this bulletin. This edition of Bulletin 102 is therefore issued in two parts, Part A dealing with the matters of wider interest, and Part B dealing more fully with the technical geologic data, and intended only for geologists and engineers. The latter bulletin is sent only when specially requested, and on receipt of postage (6 cents).

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STATUS OF DRILLING IN TIOGA REGION - MAY 1, 1932.

This list supplements pp. 11-13, Bulletin 102A, January 1, 1932. All changes of status except whether wells are shut-in or producing is noted here. A considerable number of wells are now producing part or all of the time.

n ap	Name of well		Reported owners	County	Township	Elev. well	Total depth	Elev. top Orsky.	Structure	Status	Remarks
4	Davey	#1	East Penn Dev. Co.	Tioga	Richmond	1335	5684	-3903	Wellsboro	Abandoned	Oriskany Tight dry
7	Meyers	#1	C. H. Schrack	Lycoming	Shrwsby.		5080		Muncy Valley	"	Dry. Didn't reach Orskany.
8	McKelvy	#1	Heill et al	Clrfield.	Bradford	1600	6500		Laurel Hill	"	Dry. Did not reach Orskany.
4	County Home	#1	Wells Corporation	Tioga	Charlestn.	1390		-4161	Wellsboro	S.D. 5581	Orskany. Tight dry
5	Hettick	#1	Penn-York	Bradford	Towanda	1280	5227	-3883	Towanda	Abandoned	" " "
1	Wheeler, I.B.	#1	Lycoming N.G. Co.	Tioga	Delmar	1822		-3700	Wellsboro	S.D. 5525	No production reported
6	Brad.Co.Ag.school		Penn United	Bradford	Wysox	740	5307	-4415	Towanda	Abandoned	Orsky. Tight. Dry
7	Mitchell	#1	Overtine et al	"	Troy	1140			Blsbrg.Syn.	S.D. 4025	
2	Morris	#1	Scranton Water Co.	"	Orwell	925			Rome	S.D. 4420	
6	Croft	# 1	Universal Oil & Gas	Tioga	Lawrence	1226	4138	-2870	Sabinsville	Abandoned	Dry
7	Scofield	#1	W. W. Keefer et al	"	Richmond	1445			Wellsboro	S.D. 5490	
1	Gee, Leander		Shaler Oil Co.	"	Mdlbury.	1514	5300		Sabinsville S.flank	Abandoned	Dry. Did not reach Orskany.
3	West, Wm.		Lester & Miller	"	Tioga	1065		-4696	Pine Cr.Syn.	S.D. 5764	
6	Hughes		Mideast Oil & Gas	"	"	1432			Sabinsville	S.D. 4742	
2	Meaker	#2	Penn United	"	"	1702	6045		"	Abandoned	Dry. Did not reach Oriskany
4	Butters	#1	Morris Run Coal Co.	"	Union	1410	5383	-3805	Towanda	"	Oriskany. Tight, Dry
5	Hall, E. J.	#1	East Penn Dev. Co.	"	Fmgton.	1763	4142	-2366	Sabinsville	8,300,000	
6	Gee, Lec		Allen Reed	"	Lawrence	1286	3954	-2656	"	Abandoned	S.W. 3948
7	Emporium Lumb.Co.		East Penn Dev. Co.	Potter	E.Fork Dist.	1934			Marshfield	Dr. 5290	
8	Brown, P.M.		Penn-York	Bradford	Stevens	1260			Towanda	S.D. 6290	
9	Dickinson		York-Penn	"	W.Brlgtn.	1245	5450		Blsburg.Syn.	Abandoned	No Onondaga No Oriskany
0	Updegraff		Updegraff et al	Tioga	Rutland	1650			Wellsboro	S.D. 5490	
1	Wilston		Penn United	"	Fmgton.	1606	4072	-2445	Sabinsville	4,000,000	

	Learn, Dana (R.R. Murray #1)	#1	Mutual Nat. Gas Co.	Tioga	Lawrence	1649	4109	- 2446	Sabinsville	11,750,000	
3	Kennedy	#1	Keefer, W. W.	Bradford	Ulster	1445				S.D. 4320	
4	Presby.Church Lot	1	Mutual Nat. Gas Co.	Tioga	Fmgton.	1845			Sabinsville	S.D. 1850	
5	Bryant	#1	Shaler et al	"	Tioga	1120			"	Rig standing	
6	Wheeler, F.	#1	Rose & Vaughn	"	"	1304			"	" "	
7	Mc Cllum	#1	Workman et al	"	Fmgton.	1559	4110	- 2544	"	Abandoned	Salt water
8	Thomas, Chas.	#1	East Penn Dev. Co.	"	"	1834	4115	- 2276	"	25,500,000	
0	Smith, J. N.	#1	" " " "	"	Lawrence	1836	4233	- 2386	"	6,000,000	
1	Wolridge	#1	Heil et al	Clrfield.	Bradford				Laurel Hill N. flank	Dr. 2500	About 3 mi.N.28 W of McKelvy well
2	Champlain	#1	Reed et al	Potter	Allegheny				Hebron	Dr. 2965	About $2\frac{1}{4}$ mi.S.75 E of Booth #1 well
3	Fletcher	#1	Penn United	Tioga	Lawrence	1723	4061	- 2324	Sabinsville	3,000,000	About 4500' N.45 E of Van Zile well
4	Russell, Ida	#2	" "	"	Fmgton.	1696	4156	- 2432	"	12,000,000	About 1500' NW.of Ashton #1
5	Colegrove	1B	North Branch Dev.	"	Lawrence	1395	3695	- 2279	"	4,000,000	About 2000' E. of Colegrove 1A
6	Sturdyvant	#1	Lycoming Nat. Gas Co.	Potter	Hebron				Hebron	Foundation	About $\frac{1}{2}$ mi.S.77 W. of Booth #1
7	Tassel	#1	Schrack et al	"	"	2085			"	Dr. 1385	About $1\frac{1}{4}$ mi. E. of Booth #1
8	Murray, R. R.	#1B	North Branch Dev.Co.	Tioga	Lawrence				Sabinsville	Dr. 2110	About 1800' E. of Wilston & Kuhl #1
9	Clair	#1	Rogers et al	Potter	Hebron	2190			Hebron	Moving in	About $1\frac{1}{4}$ mi. NE. of Booth #1
0	Nugent	#1	Williamsport Nat.Gas	"	"				"	Dr. 575	About 3/8 mi.S.E. of Booth #1
1	Booth	#2	Hungiville et al	"	"				"	Location	About $\frac{1}{4}$ mi. N.W. Booth #1
2	Matteson	#1	Potter Dev. Co.	"	"				"	Moving in	S.W. corner of Hebron Twp.
3	Murray, R. R.	#2	Mutual Nat. Gas	"	Lawrence				"	" "	

INTRODUCTION

By Geo. H. Ashley

More than a year has passed since commercial gas was found in the Tioga field. The question, "What of the future?" is asked today as often as a year ago and is almost as difficult to answer. Certain facts are clear. First is the presence of at least one and probably two large gas fields in the Oriskany sand in northeast Pennsylvania. Second is the irregular occurrence of the gas, an irregularity probably related to the broken character of the structure as shown by drilling in Tioga field and by studies on the surface. Third the presence of gas in two localities makes it appear reasonable that gas occurs at other localities. Fourth the number of dry holes drilled close to productive wells suggests that a dry hole here and there is not full proof that gas does not exist near by. It is rather to be expected that future drilling will reveal other gas fields, some of which may be large.

On the other hand no adequate test of the endurance of one of these fields has yet been made. The existance of such large wells (up to 70 million cu.ft. a day) in a sand of such small pore space (4% - 11.8%) suggests that the gas is coming from crevices or small cavities, and therefore is likely to be short-lived. Only large scale withdrawal checked against declining rock pressures will determine the matter.

Combining these conditions suggests that the Tioga field will likely produce from 25 to 50 billion cubic feet and may have many times that, depending largely upon how much the field is extended.

Attention is again called to two factors sometimes overlooked; the first is that in going from northwest to southeast the thickness of the beds that occur between the Catskill and the Oriskany increase. Thus, the interval from the base of the "red beds" or "Catskill" to the top of the Oriskany sandstone is 4400 feet on Genesee River, 5268 feet at Bradford, 6500 feet at Altoona, 6969 feet at Lock Haven, and 5850 feet at Stroudsburg. The apparent thinning of this interval at Stroudsburg is partly accounted for by the fact that toward the east the "Catskill red beds" include rocks much lower in the series. At Bradford the Catskill itself is only 538 feet thick, at Stroudsburg 3650 feet thick.

The second factor is the fact that, as judged by the decreasing percentage of volatile matter in the coals of this region, (Blossburg field, 20 per cent; Barclay field, 18 per cent; Bernice field, 9 per cent; Anthracite field 2 to 7 per cent) the chances of large volumes of gas occurring in the rocks would appear to decrease from northwest to southeast. By the same reasoning there would appear to be little likelihood of commercial quantities of oil being found east or south of western Tioga County.

STATUS OF DRILLING, WITH NOTES ON GEOLOGY

By Stanley H. Cathcart

Introduction. Gas was discovered in the Oriskany sand on the Sabinsville anticline in Farmington Township, Tioga County in September 1930. January 1, 1932, 100 locations had been tested, or were being tested, in Tioga and adjacent region. Sixty-three wells have been completed to the Oriskany, of which 36 are failures and 27 are producers. The aggregate initial daily production, most of which is still shut-in, is estimated to be something like 450,000,000 cubic feet. Wells range in size from 2 to 70 million cubic feet in 24 hours and the rock pressure averages between 1600 and 1700 pounds per square inch.

Twenty-six of the successful wells are in the Tioga field, the 27th is on the Hebron anticline in Potter County. Thirty-three failures are on the Sabinsville anticline, two are on the Wellsboro and one is on the Harrison anticline. About 12 of the failures may be said to be within the limits of Tioga field.

The 100 locations are distributed as follows: Bradford County 9, Susquehanna County 1, Potter County 3, Clearfield County 1, Lycoming County 1 and Tioga County 85. Of the 85 wells in Tioga County some 50 odd are located in and about the Tioga field.

Four anticlines that lie southeast of the Sabinsville anticline, the Marshfield, Wellsboro, Rome and Towanda, are being tested by 8 wells that appear to be favorably located on structure.

Pertinent data relating to the wells completed and to locations active are given on another page. All wells and their relation to the surface trace of anticlinal axes are shown on maps attached to this paper.

Significance of developments. General. All except one of the successful wells are located within an area 10 miles long and 3 miles wide. The "Tioga Field." That gas occurs in commercial quantity in the Oriskany sand on structure west of the Sabinsville has been proved, but that the Oriskany is gas bearing east of the Sabinsville remains to be demonstrated. Two wells have failed in the Oriskany on the Wellsboro anticline and several other wells located on the Wellsboro and Towanda structures are reported to be drilling in the Oriskany without as yet having encountered gas.

The failure of a few isolated exploratory wells does not condemn the unproven area, however, for within the Tioga field dry holes and 20,000,000-foot wells have been drilled within 1,000 feet of each other.

The Tioga field. Consideration of the subsurface data given under "Status of Drilling" shows a decided absence of conformity between surface and subsurface structure.

To the writer who studied the surface geology of the field rather carefully, the irregularities of the subsurface that have been brought out by drilling are due to faulting. This assumption is based upon the fact that even though rocks are exposed over only a small part of the surface of the field, definite evidence of faulting was observed at five localities. That any surface expression of faulting should have been observed is purely fortuitous; that many other faults exist without surface expression is probable.

Even though, an interpretation of subsurface conditions at this stage of the field's development can be little more than conjecture, we feel that a tentative analysis is permissible.

It would appear from subsurface considerations that the Sabinsville anticline in Farmington and Lawrence townships presents five specific geological elements.

1. The area east of Tioga River Valley.
2. The area west of Tioga River Valley.
    A. The Elbridge or west pool.
    B. The Beeman or east pool.
        a. The Boom or north section.
        b. The Meaker or south section.
    C. An interjacent nonproductive area.

The five elements to be considered then are 1, A, a, b, and C. We recognize the possibility that on further development the Elbridge pool may have to be subdivided and that the Boom and Meaker "sections" may each deserve recognition as a pool.

The area east of Tioga River.- Two wells have found the Oriskany sand capable but nonproductive at elevations within the range of production in either pool of the Tioga field. This circumstance, together with the physiography of Tioga River Valley, suggests that the course of the river may have been controlled by a fault zone which by preventing free movement of gas in the axial area, impounded the gas west of the river. If the probable presence of this relatively major fault feature is accepted, the faulting that we postulate in Tioga field may be viewed as accessory to the hypothetic river fault zone.

The interjacent nonproductive area - is outlined at present by the Kemp, Farr #2, (P.U.) Boom, C. Tremain, Middaugh, Elliot and Wheeler wells. Within this quadrilateral also are included the Howe, A. C. Smith, Decker, West and S. A. Smith wells. All of these 12 failures are located in what, if judged by surface geology, would appear to be [illegible] drilling territory. Four wells, the Kemp, C. Tremain, Middaugh, and P. U. Boom got a showing of salt water; four wells, the Farr's, Elliot, Wheeler and Howe got salt water in abundance and the others, A. C. Smith, Decker, West, and S. A. Smith found the Oriskany dry.

The nonproductive area is depressed relative to the areas west and east of it and it is our opinion that the depression was accomplished by a system of faults. The sudden drop of the Oriskany between Palmer #1 and Kemp and between Farr #1 and S. A. Smith suggests faulting. The presence of salt water in this area at levels productive of gas in both the Elbridge and Beeman pools suggests that this is an independent unit and possibly sealed from the adjacent units by results of faulting. Further, surface indications of faulting were observed half a mile east of the S. A. Smith well.

The trend of this zone would seem to be northeast and the amount of downthrow would appear to decrease in that direction. In defining it, we would suggest that (as a working hypothesis), its west limit be considered to be a line passing between Farr #1 and Farr #2, and Palmer #1 and Kemp #1; its north limit a line passing between Lycoming Boom #1 and Penn United Boom #1 and trending slightly north of east; its east limit as a line passing between C. Tremain and G. Burdett, Elliot and M. P. Close and east of Wheeler. This pattern will change as new wells are drilled but it would appear from data now available to be somewhat as stated.

The Elbridge pool - Developments in this pool center around Elbridge and in so far as investigated the area seems to be less complicated structurally than do the interjacent or the Beeman areas. Until shown otherwise let us accept the assumption that the nonproductive area extends west as far as a line passing between

Farr #1 and Farr #2 and Palmer #1 and Palmer #2. This then is the logically assumed east boundary of the Elbridge pool.

The subsurface axis of this pool seems to be about one-quarter mile south of the surface axis at the latitude of the Close #1 well, to cross the surface axis at about the location of Palmer #1, and to intercept the assumed Kemp-Farr fault not far east of Palmer #1.

As outlined above the Elbridge pool seems to offer exceptional drilling opportunities. The south flank may be steep and uninviting due either to asymmetry of the fold or to influence of the Farr-Kemp fault continuing west beyond Close and Bach wells; the north flank offers more encouragement and especially in the direction northeast from Close #1. This quadrilateral area as outlined by the Hoyt #1, Wilston and Kuhl, Farr #1, Palmer #1 and Leslie wells seems at present to offer the best opportunity to extend the Tioga producing area. The question to be decided by drilling, of course, is how far does the simple structure of the Elbridge area extend northeastward, or rather, how much, if any, faulting occurs northwest of the Farr-Kemp fault zone. An optimistic view seems to be warranted. There is reason to expect also that the pool will be extended somewhat west of the Place well.

The Beeman pool - appears, as indicated by the failure of the Elliot, Decker, C. Tremain, Middaugh, Herrington #2, and (P.U.) Boom wells, to be divided into a north and a south productive area which for convenience we have referred to as the Boom section and the Meaker section respectively.

The subsurface axis in the Boom section lies about half a mile north of the surface axis and the intermediate nonproductive area appears to approach near to this axis on the south. The faulted area (element C above) may extend far north of the Farr #2 locality, or as we suggest may prove to be limited at the north by a fault trending east and west between the M. G. Burdett and C. Tremain and (Lyc.) Boom and (P.U.) Boom wells. If the latter possibility is accepted as plausible then the area outlined roughly by Bancroft, Wilston and Kuhl, and Farr #1 wells becomes attractive drilling territory in any attempt to extend the Boom section. As indicated by the success of Colegrove there may also be appreciable extension northward.

The Meaker section - includes the two outstanding wells of the field, M.P. Close #1 and Meaker #1, each estimated at about 70 million cubic feet. These wells appear to be located not only on a different structure than the Boom well but on fault closure rather than on a fold;

Definite surface evidence of faulting was observed in the east half of the creek valley in which the Burdett well is located and on a creek 1 mile south of the Decker well. A line joining these two localities passes near the Close and Meaker wells.

It has been difficult for some persons to reconcile the huge capacity of the above wells with a relatively thin sand having an average porosity of about 9 per cent. Microscopic examination by Fettke of sand blown from the Farr #1 well shows that the sand is fractured and that fracture surfaces are lined with quartz crystals.

Surface and subsurface evidence both then would seem to point to production coming from fractures rather than sand pores.

The western limit of this Meaker section would seem to be a fault trending northeast and passing from a point between the M. P. Close and Elliot wells to a point east of the Middaugh well.

In summary then it would seem that while we may expect some expansion of the field by extending the margin of productive groups of wells, the greatest possibilities probably are in exploring the area that roughly is outlined by the Boom, Bancroft, Wilston and Kuhl, Hoyt, Leslie, Palmer, and Farr #1 wells.

The life of the field. With the exception of the Palmer wells, one or the other of which has been delivering gas to the Allegheny Gas Company pipe line in Cowanesque Valley for more than a year, and of the Wilston and Kuhl, Bancroft and M Burdett wells which have been delivering gas to the Pennsylvania Power and Light Line to Williamsport for about 3 months, all of the wells are shut-in. Rock pressur is said to hold up satisfactorily at the producing wells but until more wells have been turned into the line and the resulting effect on field pressure observed it wi be impossible to calculate the probable life and capacity of the field. At such time also we will be able to judge whether or not all of the wells are being supplie from one continuous reservoir or whether, as suggested above, the field consists of a number of independent units.

Product. An analysis of the gas from Palmer #1 is as follows:

(By courtesy East Penn Development Company)

Carbon dioxide	0.0
Illuminates	0.0
Oxygen	0.1
Carbon monoxide	0.0
Hydrogen	0.0
Methane	99.5
Ethane	0.0
Nitrogen	0.4

Specific gravry .58 B.t.u. 1030

Potter County. The Booth well located on the Hebron anticline, Hebron Township, Potter County was drilled into the Oriskany sand November 10, 1931, with an initial production of about 8,000,000 cubic feet and rock pressure of 2125 pounds.

Potter County has long produced gas from shallow sands, but this is the first well to produce from the Oriskany. As volume and rock pressure of the Booth compare favorably with the volumes and pressures found in the Tioga field 40 miles east there is reason to believe that a large field may be developed here.

Five anticlines that cross Potter County in a northeast direction were mapped by the Pennsylvania Survey during the summer of 1931 and are discussed under structure on another page.

Potter County in general has not been as deeply eroded as has Tioga County which means that wells will for the most part start in strata that are younger than the strata exposed on most of the anticlinal highs of Tioga County. The geologic map made by the Second Survey in 1878 shows the following distribution of formations in anticlinal areas of Potter County.

Wellsboro anticline	- Catskill appears at the surface.
Marshfield anticline	- Chemung in the principal stream valleys, Catskill on the hills.
Sabinsville anticline	- Chemung as far west as the valley of Crushing Creek; farther west Catskill in the valleys and Pottsville on the hills.
Harrison anticline	- Chemung in stream valleys as far west as Genesee River; farther west, Catskill.
Hebron anticline	- Chemung in stream valleys, Catskill on hills.
Smethport anticline	- Chemung.

In summary, excepting on the Smethport anticline erosion exposes the base of the Catskill red beds only in stream valleys, and throughout most of the length of the Harrison, Sabinsville and Wellsboro anticlines, even the stream valleys are not eroded that deeply.

It is to be expected then that, due to stratigraphic disadvantage in starting, deeper wells will have to be drilled to reach the Oriskany in the Potter County anticlines than on the Tioga County anticlines. However, this disadvantage will be offset to some extent by thinning of the strata between the Catskill and Oriskany in going from Tioga west toward McKean County. Just how much that thinning amounts to cannot be stated definitely but, basing his conclusions on intensive study of well cuttings, Fettke suggests the following:

"I have received samples from only one well in the Tioga County area that started above the base of the Cattaraugus, namely, the Weiboldt, near Leetonia in Elk Township. The interval from the base of the Cattaraugus to the top of the Oriskany is 5709 feet in this well. In the Bradford field, I make the interval between the base of the Cattaraugus and the Oriskany horizon, 4362 feet, based upon the Derrick City deep well log and other data. The Booth well in Hebron Township, Potter County is located approximately half way between these two wells and nearly in line with them. Assuming uniform thinning westward, the interval in Hebron Township should be about 5036 feet. In the Kane deep well (N.W. Elk County) the interval from the base of the Cattaraugus to the Oriskany horizon is 4698 feet. On this basis the interval would be somewhat greater than the 5036 feet mentioned above for Hebron Township. No sand was encountered at the Oriskany horizon in the Kane well."

Fettke further suggests as follows:

"I would not expect the Tully limestone to be as prominently developed in Hebron Township as it is in Tioga County. It might possibly be recognized only by careful examination of a complete set of cuttings. The interval between the Tully and the Oriskany in Hebron Township will probably be appreciably less than it is in Tioga County."

Rocks exposed at the surface in the Tioga region. The following stratigraphic section which summarizes the characteristics of the rocks exposed at the surface in the Tioga region is after Fuller's work in the Gaines-Elkland and Tioga quadrangles. A more detailed description of the formations is given in Part B of this bulletin.

Pottsville	Gurnee formation 30 - 200' ± present	Sandstone, black shale and fire clay, with 3' coal bed in upper part. Type locality vicinity of Gurnee.
	Sharon conglomerate 60 - 100'	White quartz conglomerate and sandstone.
	Unconformity	Definitely erosional, probably deformational.
	Mauch Chunk formation 0 - 100' ±	Red and green shale, and green and buff sandstone with a thin bed of fire clay and a 3' bed of limonite.

	Formation	Description
Catskill-Pocono	Oswayo ("Pocono?") formation 1100'±	Heavy beds of green and gray flaggy sandstone with some green and gray shale and local beds of red shale. In the west part of the area thin-bedded gray or buff sandstone appears to predominate in the upper 200' of the formation.
	Cattaraugus ("Catskill?") formation 500'±	Persistent red shale alternating with red, brown and green sandstone and red and green shale.
	Chemung formation 2000'± exposed	Relatively thin fossiliferous beds of gray and buff sandstone, calcareous sandstone and shale, argillaceous shale and thin beds and streaks of limestone in rapid alternation.

Formations drilled. Most wells located in the axial areas of anticlines start in the gray phase of the Chemung; many flank wells and wells located in synclines begin in the overlying red beds or "Catskill." As pointed out by Willard in Part B of this bulletin no reliable horizon marker has been recognized at the surface. The contact of the red and the gray formations is now known not to be a reliable horizon marker except perhaps when used within a decidedly restricted area. It is difficult therefore to estimate closely the relative stratigraphic position at which two wells start, even though they may not be far distant from each other.

Fortunately the subsurface is more favorable in its lithology. A limestone occurs about 1000 feet above the Oriskany seems to be quite persistent and has been used as a marker very successfully. It is known locally as the 1000-foot lime and is correlated by Fettke with the Tully. The best subsurface marker is the Onondaga limestone which immediately overlies the Oriskany. It is 20 to 30 feet thick, hard, dark and readily recognized.

As the gas occurs at or near the top of the producing sand and positive proof of the presence of salt water, if present, is had before the sand is entered far, very few wells have been drilled through the Oriskany. From data available its thickness may be said to average about 45 feet in the Tioga field and 30 feet in the western part of Tioga County. Pieces blown from various wells show it to be a fine-grained vitreous rock that Fettke finds to have porosity ranging from 4 per cent to 11.8 per cent, with an average porosity of 9 per cent for 32 samples from 10 wells examined.

Concerning the section above the Onondaga lime, the formation drilled is variously logged but sandy shale with variable lime content and a relatively small proportion of decided lime, sand and shale is shown on most drillers logs. Gray colors predominate in the upper and black or dark in the lower horizons. Red has not been logged.

Below is given the drillers log of the Shoemaker well, the deepest hole drilled in the field thus far, with correlation (by Charles R. Fettke) of the horizons drilled. Correlation is based upon intensive study of drill cuttings made by Professor Fettke for this Survey.

Log of Shoemaker #1 well, Tioga County, Pennsylvania
(Published by permission, The Lycoming Natural Gas Corporation)

Geologic Name		From	To	Geologic Name		From	To
	Gravel	24	40	Salina	Salt, white	4790	4816
Chemung	Slate, white	40	157	"	Salt,& slate, dark	4816	4990
"	Shells, limy	157	327	"	Shell, dark	4990	4992
"	Sand, gray	327	370	"	Salt, shale, dark	4992	5189
"	Sand, dark	370	400	"	Slate, dark	5189	5194
"	Slate & shell, limy	400	558	"	Slate, limy shells	5194	5237
"	Sand, dark	558	570	"	Lime, brown	5237	5289
"	Slate & shell, limy	570	603	"	Salt shale, dark	5289	5376
"	Sand, dark	603	625	"	Salt, gray	5376	5459
"	Slate & Shell, limy	625	732	"	Lime, dark	5459	5486
"	Shell, limy	732	741	"	Limy shell & slate	5486	5527
"	Slate	741	761	"	Salt	5527	5552
"	Slate & shell(gas 923)	761	1008	"	Lime, dark	5552	5565
Portage	Sand, dark	1008	1055	"	Lime	5565	5589
"	Slate and shell	1055	1252	"	Lime, dark	5589	5601
"	Sand, dark	1252	1270	"	Salt, shale	5601	5645
"	Slate and shell	1270	1289	"	Lime (little slt.wat.)	5645	5652
"	Sand, dark	1289	1318	"	Slate, white	5652	5690
"	Slate and shell	1318	1410	"	Slate, dark	5690	5770
"	Slate and shell	1410	1944	"	Slate & shell, dark	5770	5782
"	Shale, brown	1994	2080	"	Niagara lime, brown	5782	5838
"	Sand, dark	2080	2102	"	Lime, gray	5838	5844
"	Slate and shells	2102	2250	"	Lime, brown	5844	5863
"	Slate & shell, limy	2250	2480	"	Slate, gray	5863	5875
"	Slate, limy shells	2480	2532	"	Lime, gray	5875	5887
"	Slate,shell, gray	2532	2573	"	Lime, slate, gray	5887	5905
"	Slate, shell, gray	2573	2642	"	Slate, white	5905	6030
"	Slate shell, brown	2642	2720	"	Slate, dark	6030	6041
"	Shale, brown	2720	2750	"	Slate & salt, dark	6041	6047
Genesee	Shale, brown	2750	2909	"	Salt, dark	6047	6077
Tully	Shale, limy	2909	2965	"	Lime, brown	6077	6087
"	Shale, dark	2965	2980	"	Lime, black	6087	6120
"	Shale, brown	2980	2991	"	Lime,&salt, black	6120	6127
Hamilton	Shale, brown	2991	3068	"	Salt, dark	6127	6134
"	Slate,shell, dark	3068	3153	"	Lime, brown	6134	6147
"	Shale blue	3153	3360	"	Salt, gray	6147	6166
"	Lime, dark	3360	3404	"	Lime, black	6166	6172
"	Slate & shell, gray	3404	3460	"	Lime, gray	6172	6178
"	Shale, black	3460	3490	"	Lime, black	6178	6196
"	Shale, brown	3490	3707	"	Slate, dark	6196	6204
Marcellus	Shale, brown	3707	3770	"	Lime, gray	6204	6233
"	Shale, black	3770	3792	"	Salt, gray	6233	6342
"	Shale, brown	3792	3879	"	Salt & shale, dark	6342	6401
"	Shale, black	3879	3913	"	Salt, gray	6401	6410
Onondaga	Lime, black	3913	3930	"	Salt & shale, dark	6410	6418
Oriskany	Sand, gray	3930	3953	"	Slate, brown	6418	6447
"	Sand, dark	3953	3980	"	Salt, & slate, dark	6447	6508
Helderberg	Lime, dark	3980	3988	"	Lime, dark	6508	6530
"	Lime, slate & shell	3988	4018	Vernon	Slate, green	6530	6775
"	Lime, dark	4018	4261	shale	Slate, dark	6775	6794
Salina	Slate & shell, dark	4261	4430	"	Limy	6794	6799
"	Salt shale	4430	4782	"	Slate, dark	6799	6817
"	Shale, brown	4782	4790	"	Shale, green	6817	6880
				"	Slate, dark	6880	6963
				"	Slate, light	6963	7019
				"	Red rock	7019	7148
					T.D.		7148

The Medina sand. It is probable that certain wells in this region will be deepened in an attempt to test the Medina sandstone which is one of the producing horizons in New York.

As shown by the log of the Shoemaker well above, and by all other wells in this field that have penetrated any considerable distance below the Oriskany, the thickness of the interval between the Oriskany and the Medina is likely to be greatly increased by the presence of salt. Fettke estimates that the Shoemaker probably would not have entered the Medina at less depth than 7800 - 8000 feet.

Structure. The structures being drilled are very definite folds that have fairly broad crests and show flank dips of the order of magnitude 8 to 12 degrees. Certain of them appear to be essentially symmetrical but with somewhat steeper southeast than northwest limb. Others show pronounced asymmetry, in which event faulting may be a prominent feature of the south limb. The axes trend north of east, are sinuous and plunge and rise to form a series of domes and saddles. The amplitude of the folds as shown by drilling may exceed 2500 feet.

The anticlines in Tioga, Bradford, Potter, Cameron, northern Clinton and western Susquehanna counties have been studied by this Survey in a somewhat detailed reconnaissance manner. Especial attention has been paid to the position of the axial lines, the characteristics of the limbs of the folds and to the occurrence of marked domes and saddles in the axial areas. Domes and other structures that may prove favorable to gas accumulation were observed as follows. (See regional map attached)

Hebron anticline - Hebron and Allegheny townships, Potter County.
Harrison anticline - Homer and Sweden townships, Potter County.
Sabinsville anticline - Summit and North Sylvania townships, Potter County.
Farmington and Lawrence townships, Tioga County.
Marshfield anticline - Abbot Township, Potter County.
East Fork District and Wharton Township, Potter County.
Wellsboro anticline - Delmar Township, Tioga County
Richmond and Charlestown townships, Tioga County.
Columbia and Wells townships, Bradford County
(Terrace west of Austinville)
Ridgebury Township, Bradford County.

There is also some evidence of doming between Elk Township, Tioga County, and Leidy Township, Clinton County, but data available are not sufficient to localize a favorable structure.

Rome anticline - Rome and Orwell townships, Bradford County.
Apolacon and Choconut townships, Susquehanna County.
Towanda anticline - Union Township, Tioga County.
Burlington and North Towanda townships, Bradford County.
Wilmont anticline - Wilmont Township, Bradford County.
Braintrim Township, Wyoming County.
Albany Township, Bradford County, (Terrace at Laddsburg)
Wilmont Township, Bradford County (Nose)

Most of the domed areas show appreciably steepened south limbs, and on several of them evidence of faulting was observed, as follows: (see maps attached) on the Harrison anticline in Portage Township, Potter County; Sabinsville anticline in Chatham, Tioga and Lawrence townships, Tioga County; Wellsboro anticline, Ridgebury Township, Bradford County; Towanda anticline, four localities east of Towanda.

The Towanda anticline between Liberty and Towanda has south flank dips of 45° to 90°. Steep dips occur close to the axial area and (although actual fault surfaces were not observed) probably are an expression of faulting.

Field practice. Standard rigs are used on all locations. Common practice is to run 100 to 200 feet of 10-inch surface pipe, to set 700 to 900 feet of 8-inch water string and to cement about 4,000 feet of 6-inch above the Oriskany. The gas commonly occurs at or near the top of the sand. Drilling is not difficult. A water sand may be expected within the first 300 feet and commonly but little additional water is encountered before the 8-inch casing is set. After setting the 8-inch the wells are drilled practically dry and the formation stands up well.

Drillers logs are kept on all wells and most wells are being sampled. Modern subsurface methods are practiced by most of the larger operators. Aerial photographic maps have been made of Tioga, Bradford, Potter, west Susquehanna and northwest Wyoming counties for operating companies. Critical parts of the region have been studied geologically by interested companies in considerable detail and some geophysical work has been done.

Literature. The Tioga field proper falls within the area that is included in Gaines folio and the Elkland-Tioga folio of the Geologic Atlas of the United States published by the U. S. Geological Survey. These folios are out of print, but can be consulted at libraries. They present the general geology of this region and show by 100-foot contours on the top of the Chemung formation the character of the major structural features in most of the area that they cover.

The geology of the region adjacent to the area covered by the folios is mapped and described in publications of the Second Geological Survey of Pennsylvania. These publications also are out of print but may be consulted in libraries.

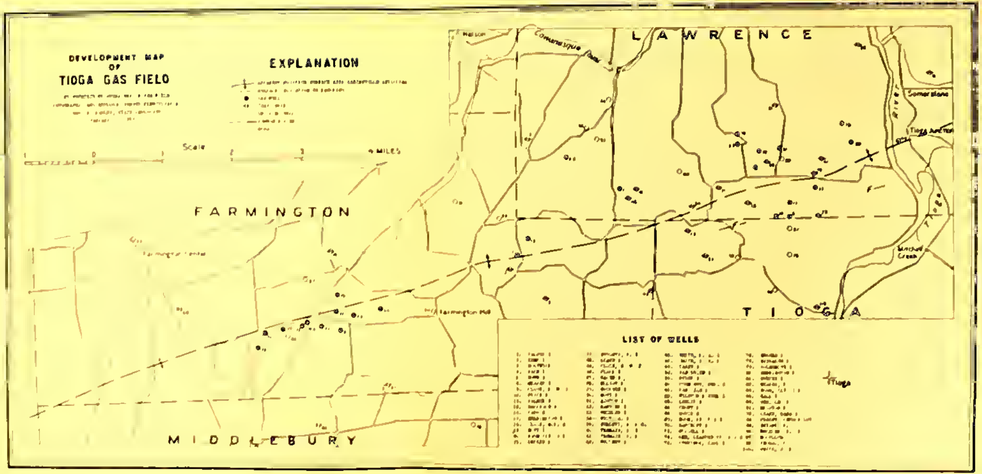
County maps of most counties included on the map attached may be obtained from the Pennsylvania Highway Department for 50 cents each.

The accompanying maps attempt to outline the major structural features of the Tioga region, and to show the geographic position of well locations referred to in this text.

Work of the Pennsylvania Survey. In January 1931 this Survey issued Bulletin 102, a compilation of geologic data from various sources, together with an outline of developments. This edition of Bulletin 102 is issued to meet a demand for information on the Tioga region that has exhausted five preceeding editions and still continues. For much of the information it contains the Survey is indebted to companies operating in the region, especially the East Penn Development Company, Penn United Gas Company, and the Lycoming Natural Gas Corporation.

During 1931 members of the Survey staff traced anticlinal axes in this region as noted above under structure. Well cuttings were collected and studied in detail for the Survey by Charles R. Fettke, and a regional study of the stratigraphy was made by a member of the staff. The results of the subsurface and stratigraphic studies are published in Bulletin 102B.

It is planned to publish data that may be collected from time to time in mimeographed bulletin form and when advisable to issue a more comprehensive writing.


DEVELOPMENT MAP
OF
TIOGA GAS FIELD
EXPLANATION
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4 MILES
LAWRENCE
FARMINGTON
MIDDLEBURY
TIOGA
Nelson
Cowanesque River
Somerstone
Tioga Junction
River
Mitchell Creek
Farmington Center
Farmington Hill
Tioga
LIST OF WELLS

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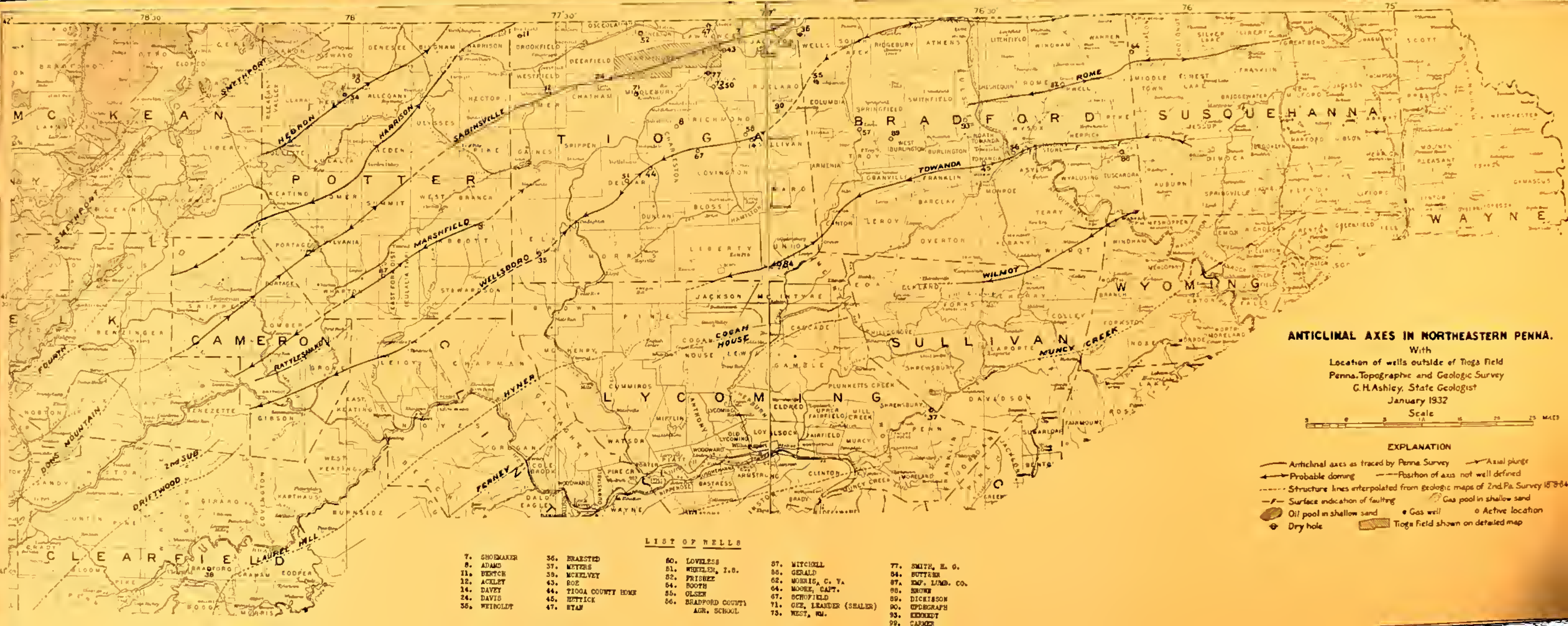

ANTICLINAL AXES IN NORTHEASTERN PENNA.

With
Location of wells outside of Tioga Field
Penna. Topographic and Geologic Survey
G. H. Ashley, State Geologist
January 1932

LIST OF WELLS

7.	SHOEMAKER
8.	ADAMS
11.	BERTCH
12.	ACKLEY
14.	DAVEY
24.	DAVIS
35.	WEIBOLDT
36.	BRAKSTED
37.	MEYERS
38.	MCKELVEY
43.	ROE
44.	TIOGA COUNTY HOME
45.	HETTICK
47.	RYAN
50.	LOVELESS
51.	WHEELER, I. S.
52.	FRISBEE
54.	BOOTH
55.	OLSEN
56.	BRADFORD COUNTY AGR. SCHOOL
57.	MITCHELL
58.	GERALD
62.	MORRIS, C. V.
64.	MOORE, CAPT.
67.	SCHOFIELD
71.	GEE, LEANDER (SHALER)
73.	WEST, WM.
77.	SMITH, H. G.
84.	BUTTERS
87.	EMP. LUMB. CO.
88.	BROWN
89.	DICKISSON
90.	UPDEGRAPH
93.	KENNEDY
99.	CARMER

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Status of drilling in Tioga Region, Pennsylvania January 19[illegible]2

No. on map	Name of well		Reported owners	County	Township	Elev. well	Total depth	Elev. top Orsky.	Structure	Status	Results
1	Palmer	#1	East Penn Dev. Co.	Tioga	Fmgton.	1764	4012	-2242	Sabinsville	Producing	2,600,000
2	Kemp	#1	" " " "	"	"	1712	5375	-2638	"	Abandoned	Sh.salt water
3	Bostwick	#1	J. E. Trainer	"	Lawrence	1509	4197	-2682	"	"	Salt water
4	Farr	#1	Lycoming N. G. C.	"	"	1367	3782	-2406	"	Shut in	10,000,000
5	Howe, Est.	#1	" " " "	"	Fmgton.	1743	4391	-2632	"	Abandoned	Salt water
6	Meaker	#1	Penn United	"	Lawrence	1677	4203	-2520	"	Shut in	70,000,000
7	Shoemaker	#1	Lycoming N. G. C.	"	"	1474	7148	-2458	"	Abandoned	Dry sand
8	Adams	#1	Adams Gas & Oil Co.	"	Chlstn.	1317			Wellsboro	S.D. 4950	
9	Close, E. W.	#1	Lycoming N. G. C.	"	Fmgton.	1755	4022	-2263	Sabinsville	Shut in	25,000,000
10	Price, E. E.	#1	" " " "	"	"	1676	4285	-2600	"	Abandoned	Salt water
11	Bertch	#1	Segar Oil & Gas Co.	"	Brkfld.	1840	4921	-3024	Harrison	"	Dry sand
12	Ackley	#1	Lycoming N. G. C.	"	Clymer	1934	5083	-3086	Sabinsville	"	" "
13	Palmer	#2	East Penn Dev. Co.	"	Fmgton.	1849	4095	-2244	"	Producing	23,000,000
14	Davey	#1	" " " "	"	Richmond	1335		-3950	Wellsboro	Dr. 5285	
15	Harrison	#1	Leonard Oil Co.	"	Lawrence	1049	3750	-2432	Sabinsville	Abandoned	Dry sand
16	Farr	#2	Lycoming N. G. C.	"	"	1687	4203	-2511	"	"	Salt water
17	Herrington	#1	" " " "	"	"	1720	4220	-2498	"	Shut in	25,000,000
18	Close, H. P.	#1	" " " "	"	"	1634	4135	-2500	"	" "	70,000,000
19	Hoyt	#1	" " " "	"	Fmgton.	1680	4037	-2350	"	" "	13,000,000
20	Boom	#1	" " " "	"	Lawrence	1563	3811	-2244	"	" "	20,000,000
21	Decker	#1	" " " "	"	"	1501	4781	-3194	"	Abandoned	Dry sand
22	Burdett, G.	#1	Penn United	"	"	1572	4145	-2567	"	Shut in	7,000,000
23	Learn	#1	East Penn Dev. Co.	"	Fmgton.	1837	4069	-2231	"	" "	22,000,000
24	Davis	#1	Penn United	"	Chatham	1707	4723	-2965	"	Abandoned	Dry sand
25	Close, E. W.	#2	Lycoming N. G. C.	"	Fmgton.	1747	4036	-2283	"	Shut in	13,000,000
26	Place	#1	" " " "	"	"	1849	4280	-2423	"	" "	4,800,000
27	Bache	#1	Williamsport Oil & G.	"	"	1645	4956	-3242	"	Abandoned	Dry sand
28	Elliot Heirs	#1	Sylvania Co.	"	Lawrence	1506	4134	-2623	"	"	Salt water
29	Buckbee	#1	Manufacturers Gas	"	"	1542	4254	-2712	"	"	" "
30	Hoyt	#2	Lycoming N. G. C.	"	Fmgton.	1730		-2391	"	Shut in	7,250,000
31	Ashton	#1	" " " "	"	"	1625	3977	-2345	"	" "	10,000,000
32	Manning	#1	East Penn Dev. Co.	"	"	1785	4103	-2313	"	" "	15,000,000
33	Wheeler, F.	#1	Penn United	"	Tioga	1580	4322	-2735	"	Abandoned	Salt water
34	West, A.	#1	Lycoming N. G. C.	"	Lawrence	1564	4760	-3148	"	"	Dry sand
35	Weiboldt	#1	Moody Seagraves	"	Elk	1870	6045	-4122	Wellsboro	"	" "
36	Braested	#1	Moiserville Oil & Gas	Bradford	Wells	1600	4750	-3119	Sabinsville	"	" "
37	Meyers	#1	C. H. Schrack	Lycoming	Shrwsby				Muncy Valley	S. D. 4000	
38	Mc Kelvey	#1	Heill et al	Clrfield.	Bradford	1600			Laurel Hill	S.D. 5800	

39	Burdett, M. & G.	#1	North Branch Dev. Co.	Tioga	Lawrence	1273	3647	-2317	Sabinsville	Shut in	2,000,000
40	Tremain, J.E.	#1	Penn United	"	"	1005	3980	-2350	"	" "	150,000
41	" , Chas.	#1	Lycoming N. G. C.	"	"	1531	4130	-2468	"	Abandoned	Sh. salt water
42	Whitney	#1	Morgan Hague	"	Fmgton	1561	4780	-3203	"	"	Salt water
43	Roe	#1	Wier & Thorn	"	Lawrence	1406	4249	-2778	"	"	Dry sand
44	County Home	#1	Wells Corporation	"	Chlstn.	1390			Wellsboro	Dr. 5315	
45	Hettick	#1	Penn-York	Bradford	Towanda	1280		-3883	Towanda	" 5167	
46	Smith, A. C.	#1	East Penn Dev. Co.	Tioga	Lawrence	1487	4692	-3093	Sabinsville	Abandoned	Dry sand
47	Ryan	#1	Morgan Hague	"	"	1056	4298	-3196	"	"	" "
48	Smith, S. A.	#1	Penn United	"	Tioga	1558	4416	-2750	"	"	" "
49	Carey	#1	Wade & Moore	"	"	1038	4317	-3247	"	"	" "
50	Loveless	#1	Taylor - Lynch	"	"	1187	6028	-4823	Pine Cr.Syn.	"	" "
51	Wheeler, I.B.	#1	Lycoming N. G. C.	"	Delmar	1820		-3699	Wellsboro	Dr. 5529	
52	Frisbee	#1	Elkland Oil & Gas	"	Nelson	1436			CowanesqueS.	S.D. 4200	
53	Van Duzen	#1	" " "	"	Fmgton.	1814			Sabinsville	" 4585	
54	Booth	#1	Hungiville & Co.	Potter	Hebron	1847	4925	-3076	Hebron	Shut in	7,500,000
55	Olsen	#1	Jas. Duff et al	Bradford	Columbia	1856		-3789	Wellsboro	S.D. 5690	
56	Brad.Co.Ag.School		Penn United	"	Wysox	740			Towanda	S.D. 5307	
57	Mitchell	#1	Overtine et al	"	Troy	1140			Blsbrg.Syn.	S.D. 2961	
58	Gerald	#1	Lyons et al	Tioga	Richmond	1349			Wellsboro	S.D. 2880	
59	Ryder	#1	Brad. Lawrence	"	Lawrence	1224	4013	-2781	Sabinsville	Abandoned	Dry sand
60	Cummings, Geo.	#1	Vaughn & Rose	"	Mdlbury.	1756		-3222	"	"	" "
61	Van Zile	#1	Mellon & Pollock	"	Lawrence	1523	3768	-2241	"	Shut in	25,000,000
62	Morris	#1	Scranton Water Co.	Bradford	Orwell	925			Rome	Dr. 4355	
63	Wilston & Kuhl		North Branch Dev. Co.	Tioga	Lawrence	1573	4040	-2462	Sabinsville	Shut in	13,500,000
64	Moore, Capt.	#1	Lk. O'Medowis O.&G.	Susq.	Appolacon	1575			Rome	S.D. 4400	
65	Leslie	#1	East Penn Dev. Co.	Tioga	Fmgton.	1893	4088	-2192	Sabinsville	Shut in	40,000,000
66	Croft	#1	Universal Oil & Gas	"	Lawrence	1226			"	S.D. 4070	
67	Scofield	#1	W. W. Keefer et al	"	Richmond	1445			Wellsboro	" 3020	
68	House, Bertha	#1	North Branch Dev. Co.	"	Fmgton.	1777	4666	-2938	Sabinsville	Abandoned	Dry sand
69	Penn United Boom	#1	Penn United	"	Lawrence	1696	4187	-2386	"	"	Sh.salt water
70	Barcroft		North Branch Dev. Co.	"	"	1609	3982	-2335	"	Shut in	6,000,000
71	Gee, Leander		Shaler Oil Co.	"	Mdlbury.	1514			" S. flank	S.D. 4750	
72	Russell		Penn United	"	Fmgton.	1646	4010	-2338	"	Shut in	10,000,000
73	West, W.		Lester & Miller	"	Tioga	1065			Pine Cr.Syn.	Dr. 5412	
74	Gee, Leander		Penn United	"	Fmgton.	1812	4274	-2442	Sabinsville	Shut in	4,250,000
75	Cummings, Earl		Hultsinger et al	"	Mdlbury.	1606	4110	-3497	" S. flank	Abandoned	Dry sand
76	Hughes	#1	Midwest Oil & Gas	"	Tioga	1432			"	Dr. 4293	
77	Smith, H. G.	#1	Tallaferro	"	"	1040	5306	-4195	" S. flank	Abandoned	Dry sand
78	Middaugh	#1	North Branch Dev. Co.	"	Lawrence	1673	4672	-2931	"	"	" "
79	Colegrove	#1	" " " "	"	"	1610	4004	-2340	"	Shut in	2,500,000
80	Herrington	#2	Lycoming N. G. C.	"	"	1620	4113	-2473	"	Abandoned	Sh. salt water

81	Durfee #1	Workman et al	Tioga	Lawrence	1439	4019	-2543	Sabinsville N. flank	Abandoned	Dry sand
82	Meaker #2	Penn United	"	Tioga	1702			"	Dr. 4485	
83	Beem #2	Lycoming N. G. C.	"	Lawrence	1732	4036	-2297	"	Shut in	4,500,000
84	Butters #1	Morris Run Coal Co.	"	Union	1000			Towanda	Dr. 3335	
85	Hall #1	East Penn Dev. Co.	"	Fmgton.	1763			Sabinsville	Dr. 4100	
86	Gee, Leo #1	Allen Reed Trustee	"	Lawrence	1286			"	S. D. 652	
87	Emporium Lumb. Co.	East Penn Dev. Co.	Potter	E. Fork Dist.	1934			Marshfield	Dr. 1100	
88	Brown #1	Penn York	Bradford	Stevens	1260			Towanda	Dr. 6057	
89	Dickinson #1	York Penn	"	W. Brlgtn.	1245			Blossburg S.	S. D. 5450	
90	Updegraff, C.E. #1	Updegraff et al	Tioga	Rutland				Wellsboro	Dr. 275	
91	Wilston	Penn United	"	Fmgton.	1606			Sabinsville	Dr. 2350	
92	Learn, Dana #1	Mutual Nat. Gas Co.	"	Lawrence	1649			"	Dr. 3192	
93	Kennedy #1	W. Keefer, Jr.	Bradford	Ulster				Rome	S.D. 1580	
94	Presby.Church Lot	Mutual Nat. Gas Co.	Tioga	Fmgton.				Sabinsville	Dr. 440	
95	Bryent, E.	Shaler et al	"	Tioga				"	Rig up	
96	Wheeler, F. #2	Vaughn & Rose	"	"				"	Bldg. rig	
97	McCullum	Workman et al	"	Fmgton.				"	Dr. 350	
98	Thomas, Chas.	East Penn Dev. Co.	"	"				"	Moving in	
99	Carmer	" " " "	Potter	Hebron				Hebron	Loc.	
100	Smith, J. N.	" " " "	Tioga	Lawrence				Sabinsville	Digging cellar	

Information by courtesy of companies operating in this field.
Especially the Penn United Gas Company,
East Penn Development Company,
Lycoming Natural Gas Corporation.